*International Research Journal of Environment Sciences*_____ ISSN 2319–1414
Vol. **3(4),** 51-63, April **(2014)** *Int. Res. J. Environment Sci.*

Studies on Qualitative and Quantitative Abundance of Aquatic Entomo-fauna in Glacial fed Mountainous Goriganga River of Kumaun Himalaya Uttarakhand, India

Ashok Kumar
Department of Zoology, Kumaun University, Soban Singh Jeena Campus Almora, Uttarakhand-263601, INDIA

Available online at: www.isca.in, www.isca.me
Received 30th March 2014, revised 1st April 2014, accepted 21st April 2014

Abstract

The present study was aimed to record the qualitative and quantitative abundance of aquatic entomofauna in glacial fed mountainous Goriganga River of Kumaun Himalaya from July, 2006 to June, 2008. Samples were collected from three sampling stations (sampling station 1-Jauljibi, 600msl; sampling station 2 -Baram 900msl and sampling station 3-Madkot 1300msl) which are extended in a river stretch of 44 Km. A total of 25 genera of aquatic insects (Ephemerella, Cinygmula, Baetisca, Ephemera, Iron, Megistocera, Tendipes, Antocha, Dixa, Simulium, Agabinus, stenocolus, Heterlimnius, Hydaticus, Laccobius, Hydropsyche, Hydroptela, Glossosoma, Perlomyia, Isoperla, Argia, Hagenius, Epicordulia, Argion, and Ophiogomphus) belonging to six orders (Ephemeroptera, Diptera, Coleoptera, Trichoptera, Plecoptera and Odonata) were recorded at all the stations during 2006 to 2008. Monthly, seasonal, yearly and site wise variations (qualitatively as well as quantitatively) in zoo-bentic population including similarity and dissimilarity index have also been recorded and discussed in the present paper.

Keywords: Aquatic Entomo-fauna, qualitative, quantitative, abundance, goriganga, kumaun Himalaya.

Introduction

India is one of the mega diversity countries in the world and occupies ninth position in terms of fresh water megadiversity Mittermeier et.al[1]. Fresh water makes up only 0.01% of world total water body and contains about 100000 species (8%) out of 3 million scientifically described species Dudgeon[2]. Aquatic insects are extremely important in ecological systems for many reasons Merritt et.al[3] and are primary bioindicators of fresh water bodies such as lakes, ponds, wetland, streams and rivers. They serve various purposes such as food for fishes and other invertebrates, as vectors of pathogens to both human and animals Foil[4] and Chae et.al[5]. The presence or absence of certain families of aquatic insects can indicate whether a particular water body is healthy or polluted.

Aquatic entomofauna constitute an important part of the aquatic ecosystems. These are involved in nutrients recycling and form an important component of natural food web in aquatic ecosystem. Aquatic entomo-fauna possess very important position in structural studies of lotic systems, and hence can significantly be applied as biomonitor to access the degree of ecological impact caused by various sources because of their suitable properties. Various structural properties like density, diversity etc. of aquatic entomo-fauna, in respect of temporal and spatial variations with its seasonality have been studied by many workers[6-12].

The study of benthic macro-invertebrates especially aquatic entomo-fauna, an important component of aquatic habitat, is of paramount importance in aquatic ecology and their community is an important component of river diversity, because its members are fundamental connectors among the different trophic levels of running waters.

The macro-benthic biota principally consisted of almost all the fresh water taxonomic groups of animals which have attained maximum development and diversity in mountainous rivers indicating permanency of these animals in geological history.

The benthic animals inhabiting glacial fed rivers constitute an extremely diverse assemblage, both taxonomically and ecologically. The aquatic insects and fishes by virtue of being relatively stationary and constantly exposed to changes are undergoing in overlying water and hence respond very well to pollution. As they live in river bed and attached to some objects, they are considered best indicator of water quality. Some of them constitute the food for fishes, while some others are predatory on fish larvae, fry and other aquatic biota. Some times the aquatic entomo-fauna are decimating the fish food in the river water. Therefore, a great deal of works on aquatic entomo-fauna and their biology have been made Hynes[13]. The effects of benthic fauna in aquatic ecosystems have been studied by many workers Gupta et.al.[14]; Mohan et.al.[15]; Welch[16]; Ward and Whipple[17]; Peenak[18] and Tonapai[19]. In high altitude rivers, the ecology of aquatic insects has also been made by Sharma et.al.[20]; Dobriyal[21]; Sehgal[22]; Negi[23]; Jhingran[24]; Pathani et.al.[25]. The benthic populations are usually the first and most prominent beneficiaries Vass and Zultshi[26].

Literature review suggested that there was no literature on aquatic entomofauna of Goriganga River, hence this is the first study on Qualitative and Quantitative abundance of Aquatic Entomo-fauna in glacial fed mountainous Goriganga River of Kumaun Himalaya Uttarakhand." (India) investigated for two years from July-2006 to June-2008.

Material and Methods

After the preliminary survey of Goriganga river, three sampling stations were selected Fig. 1 which are situated at different altitudes, station-1 (Jauljibi- 600 msl); station-2 (Baram- 900 msl) and station-3 (Madkot- 1300 msl) and are extended in a river stretch of 44 Km. for monthly and seasonal sampling. The aquatic entomo-fauna samples were collected from a 1 X 1 m long study area falling with in the collecting site (a reach), chosen to be reasonably typical of the particular stretch of water. Methods described by Vollen Weider[27], Hynes[28] and Trivedy and Goel[29] were employed. The collection procedure begins by washing and emptying rocks, stones / pebbles with the aid of basket sampler, forceps, qualitative devices such as dip net and hand screens. Most of the insects were found below the stones / pebbles, each stone / pebble was brushed with a stiff bristle brush to remove the clinging organisms. Other left materials such as sticks and leaves were also carefully checked before being discarded. Skillful hand picking can easily collect large size insects. The screened material was washed in a container, preserved in 5 % formalin and identified stereoscopically or with the help of optical microscope following standard literature.

Index of Similarity and Dissimilarity: Similarity and dissimilarity index is used to record the similarity and dissimilarity among different taxa in different samples Odum[30]. Similarity and dissimilarity index can be determined by the following formulae:

$$S = \frac{2C}{A+B}$$

Where S = similarity index, A = taxa in A sample, B = taxa in B sample, C = taxa common in both the samples.

Dissimilarity index = 1 – S.

Where S = similarity index.

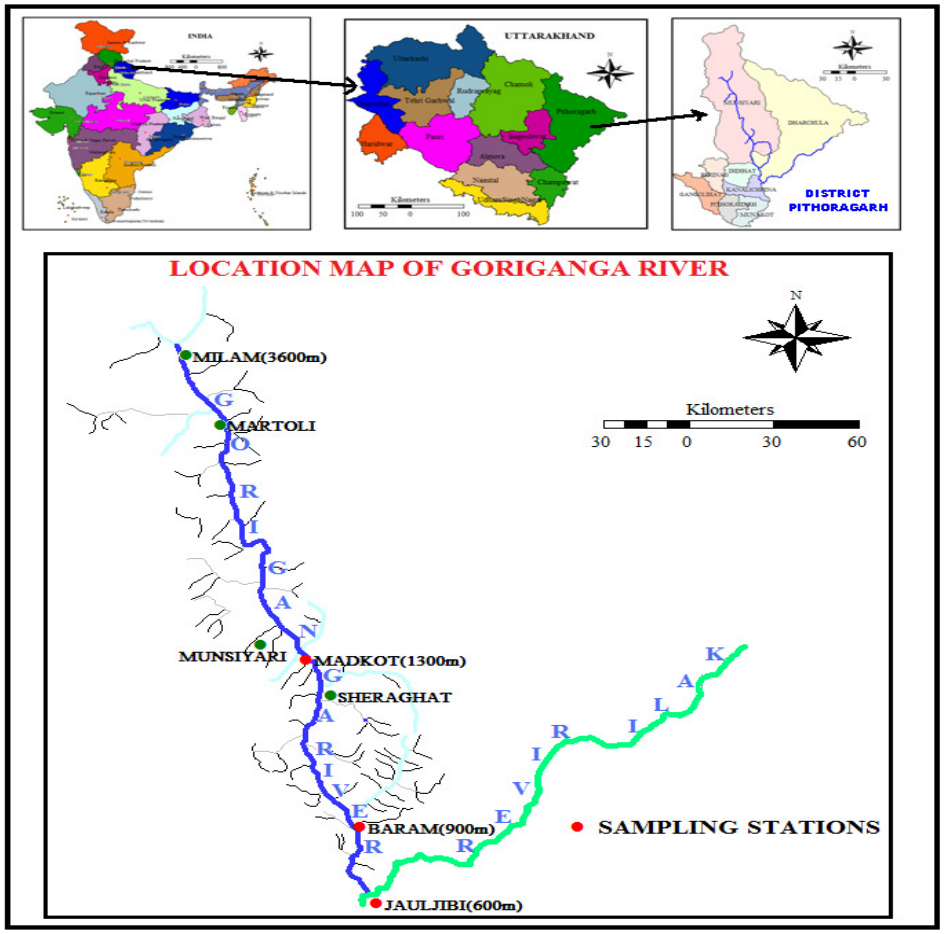

Figure-1
Location Map Showing The Three Sampling Stations, Jauljibi (600 MSL), Baram (900 MSL) and Madkot (1300 MSL) in the Gorigana River of Kumaun Himalaya

Results and Discussion

The results presented in the paper are based on the observations made on qualitative and quantitative studies of aquatic entomo-fauna. The data on aquatic entomo-faunal population have been surveyed and analyzed on monthly basis for qualitative and quantitative abundance from July, 2006 to June, 2008. The identified aquatic entomofauna has been tabulated in table 1.

Qualitative Composition of Aquatic Entomo-fauna: During the period of study i,e from July 2006 to June 2008, some total 25 genera of aquatic insects (*Ephemerella, Cinygmula, Baetisca, Ephemera, Iron, Megistocera, Tendipes, Antocha, Dixa, Simulium, Agabinus, stenocolus, Heterlimnius, Hydaticus, Laccobius, Hydropsyche, Hydroptela, Glossosoma, Perlomyia, Isoperla, Argia, Hagenius, Epicordulia, Argion, and Ophiogomphus*) belonging to six orders (Ephemeroptera, Diptera, Coleoptera, Trichoptera, Plecoptera and Odonata) were recorded in the river table 1. During first year (2006-07), some 23 genera were recorded, being maximum 16 genera (64.00%) at spot-3 followed by 15 genera (60.00%) at spot-1 and minimum 13 genera (52.00%) were recorded at spot-2 table 1. While during second year (2007-08), some 25 genera were recorded; maximum 20 genera (80.00%) at spot-1 and spot-3 and minimum 19 genera (76.00%) were recorded at spot-2. An order wise distribution showed that maximum 5 genera (20.00%) were represented by Ephemeroptera, Coleoptera and Odonata followed by 4 genera (16.00%) by Diptera, 3 genera (12.00%) by Trichoptera and minimum 2 genera (8.00%) were represented by Plecoptera at all the three spots during 2006-07 and 2007-08 in the present study table 1.

Table-1
Qualitative composition of aquatic entomofauna in the Goriganga river during 2006-07 and 2007-08

Order/Genera	July 2006-June 2007			July 2007-June 2008.		
	Jauljibi Spot-1	**Baram Spot-2**	**Madkot Spot-3**	**Jauljibi Spot-1**	**Baram Spot-2**	**Madkot Spot-3**
Ephemeroptera						
Ephemerella	+	+	+	+	+	+
Cinygmula	+	+	+	+	+	+
Baetisca	+	+	+	+	+	+
Ephemera	-	-	+	+	+	+
Iron	-	-	-	-	-	+
Diptera						
Megistocera	+	+	+	+	+	+
Tendipes	+	+	-	+	+	+
Antocha	+	+	+	+	+	+
Dixa	+	-	+	+	+	+
Simulium	+	-	+	+	+	+
Coleoptera						
Agabinus	+	-	-	+	+	-
Stenocolus	+	+	-	+	+	-
Heterlimnius	-	-	+	-	+	+
Hydaticus	-	-	+	+	+	+
Laccobius	-	-	+	-	-	+
Trichoptera						
Hydropsyche	+	+	+	+	+	+
Hydroptella	+	+	+	+	+	+
Glossosoma	-	-	-	+	-	+
Plecoptera						
Perlomyia	+	-	-	+	-	-
Isoperla	-	+	-	+	+	-
Odonata						
Argia	+	+	+	+	+	+
Hagenius	+	-	-	+	+	+
Epicordulia	-	+	-	-	+	-
Argion	-	-	+	+	-	+
Ophiogomphus	-	+	+	-	-	+
Total	**15**	**13**	**16**	**20**	**19**	**20**
Annual percentage	**60.00%**	**52.00%**	**64.00%**	**80.00%**	**76.00%**	**80.00%**
(+ = present and - = absent)						

Monthly qualitative analysis of aquatic entomo-faunal diversity at three spots in the Goriganga river during 2006-07 and 2007-08 has been depicted in tables 2, 3 and 4. On perusal of table 2 and fig.2, it can be seen that maximum (15) genera of aquatic insects were recorded in the month of December followed by November (14), September, October, January and April (13), March (11), February (10), May (09), June (07). A minimum (06) genera was recorded in the months of July and August at spot-1 (Jauljibi); at spot-2 (Baram), the maximum (13) genera were recorded in the month of November followed by October, January, March, April and May (11), December (10), September and February (09), June (07) and minimum (05) genera were recorded in the months of July and August table 3 and figure 3, whereas at spot-3 (Madkot), the maximum (12) genera were recorded in the months of January, February and April followed by September and December (11), October and May (10), November and March (09), August (08) and minimum (07) genera were recorded in the months of June and July during first year (2006-07) table 4 and figure 4. During second year (2007-08), the maximum (17) genera of aquatic entomo-fauna were recorded in the month of December followed by October and January (15), March (14), February and April (13), September (12), November and May (11), August (08), July (06) and minimum (05) genera were recorded in the month of June at spot-1 (Jauljibi) table 2 and figure 2; at spot-2 (Baram), the maximum (13) genera were recorded in the months of September, November, and February followed by October and January (12), December, March and May (11), April (10), August and June (08) and minimum (07) were recorded in the month of July table 3 and figure 3, whereas at spot-3 (Madkot), the maximum (15) genera were recorded in the months of February and March followed by September and November (14), January and April (12), December (11), October and March (10), August and June (08) and minimum (06) genera were recorded in the month of June in the present study table 4 and figure 4.

Table 2
Qualitative composition of aquatic entomo-fauna at spot-1 (Jauljibi) in the Goriganga river during 2006-07 and 2007-08

Order/Genera	Monthly qualitative analysis of Aquatic entomo-fauna at spot-1 (Jauljibi) in the Groriganga river during 2006-07 and 2007-08.																							
	July		Aug		Sept		Oct		Nov		Dec		Jan		Feb		March		Apr		May		Jun	
Ephemeroptera	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Ephemerella	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
Cinygmula	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	+
Baetisca	+	-	-	-	+	-	+	+	+	-	+	+	-	+	-	-	+	-	+	+	-	-	-	-
Ephemera	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	+	-	+	-
Iron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																								
Megistocera	-	-	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+
Tendipes	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-
Antocha	-	-	-	-	+	+	+	-	+	-	+	+	-	+	-	-	-	+	+	+	-	+	-	-
Dixa	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-
Simulium	-	-	-	-	+	-	+	+	+	-	+	+	+	-	+	-	+	+	-	+	-	-	-	-
Coleoptera																								
Agabinus	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+	+	-	+	+	-
Stenocolus	-	-	-	-	-	+	-	+	+	-	+	-	+	+	+	-	-	+	+	+	+	+	-	+
Heterlimnius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydaticus	-	-	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	+	-	-
Laccobius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera																								
Hydropsyche	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-
Hydroptella	+	+	+	+	+	-	+	-	+	-	+	+	+	-	-	+	-	+	+	+	+	+	-	-
Glossosoma	-	-	-	-	-	+	-	+	-	+	-	-	-	-	-	+	-	+	-	+	-	-	-	+
Plecoptera																								
Perlomyia	+	-	+	-	+	-	+	-	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	-
Isoperla	-	-	-	-	-	+	-	+	-	-	-	+	-	+	-	+	-	+	-	-	-	-	-	-
Odonata																								
Argia	-	+	-	+	+	-	+	+	+	-	+	+	+	-	-	+	+	-	+	-	-	-	+	-
Hagenius	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
Epicordulia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Argion	-	-	-	-	-		-	-	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-	-
Ophiogomphus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	06	06	06	08	13	12	13	15	14	11	15	17	13	15	10	13	11	14	13	13	09	11	07	05

{I = during first year- 2006-07; II = during second year-2007-08; + = present and - = absent)

Out of 25 genera of aquatic insects, 8 genera (*Ephemerella, Cinygmula, Baetisca, Megistocera, Antocha, Hydropsyche, Hydroptella* and *Argia*) were fairly common at all the spots table 1. The Ephemeroptera (mayflies) nymps, Coleoptera (water beetles) both larvae and adults and Odonata (dragonflies) formed the major bulk, the Diptera (true flies), Trichoptera (caddisflies) and Plecoptera (stoneflies) were next in the line. The aquatic insects were generally found concealed under stones, gravel and rocks. The stone flies (Plecoptera) were present exclusively in the riffles and Odonata (dragon flies) and Coleoptera (water beetles) in slow and stagnant conditions. Others such as mayflies (Ephemeroptera), Caddisflies (Trichoptera), trueflies (Diptera) were common to both the habitats.

Table-3
Qualitative composition of aquatic entomofauna at spot-2 (Baram) in the Goriganga river during 2006-07 and 2007-08

Order/Genera	Monthly qualitative analysis of Aquatic entomo-fauna at spot-2 (Baram) in the Groriganga river during 2006-07 and 2007-08.																							
	July		Aug		Sept		Oct		Nov		Dec		Jan		Feb		March		Apr		May		Jun	
Ephemeroptera	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Ephemerella	-	-	-	-	-	+	+	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-
Cinygmula	+	+	+	-	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+
Baetisca	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	+
Ephemera	-	+	-	+	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	-	-	+	-	-
Iron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																								
Megistocera	-	+	-	-	-	-	+	-	+	+	+	-	+	-	-	+	-	-	+	+	+	-	-	-
Tendipes	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Antocha	+	+	+	+	+	-	-	-	+	+	-	-	+	-	+	+	+	+	+	-	-	-	+	-
Dixa	-	-	-	-	-	+	-	+	-	+	-	-	-	+	-	+	-	-	-	-	-	+	-	-
Simulium	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-
Coleoptera																								
Agabinus	-	-	-	+	-	+	-	+	-	-	-	+	-	+	-	+	-	+	-	-	-	-	-	-
Stenocolus	+	+	+	+	+	-	+	-	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+
Heterlimnius	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-
Hydaticus	-	-	-	-	-	+	-	+	-	-	-	+	-		-	-	-	-	-	+	-	+	-	+
Laccobius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera																								
Hydropsyche	-	+	-	-	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	-	-	+
Hydroptella	+	-	+	+	+	+	+	+	+	-	+	-	+	+	-	-	+	-	+	-	+	+	+	-
Glossosoma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plecoptera																								
Perlomyia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Odonata																								
Argia	-	-	-	-	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	-	-
Hagenius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+
Epicordulia	-	-	-	-	-	+	+	+	+	+	-	-	-	+	-	-	+	+	-	+	+	+	-	-
Argion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiogomphus	-	-	-	-	+	-	-	-	+	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-
Total	05	07	05	08	09	13	11	12	13	13	10	11	11	12	09	13	11	11	11	10	11	11	07	08

{I = during first year- 2006-07; II = during second year-2007-08; + = present and - = absent)

Table 4
Qualitative composition of aquatic entomo-fauna at spot-3 (Madkot) in the Goriganga river during 2006-07 and 2007-08

Order/Genera	Monthly qualitative analysis of Aquatic entomo-fauna at spot-3 (Madkot) in the Groriganga river during 2006-07 and 2007-08.																							
	July		Aug		Sept		Oct		Nov		Dec		Jan		Feb		March		Apr		May		Jun	
Ephemeroptera	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Ephemerella	-	-	-	+	+	+	+	-	+	+	-	+	-	+	+	+	+	-	+	-	-	+	+	-
Cinygmula	+	+	+	-	+	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+
Baetisca	+	+	-	+	-	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+	-	-
Ephemera	-	-	+	-	-	+	+	+	+	+	+	+	-	-	-	+	+	-	+	+	+	-	+	+
Iron	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	-
Diptera																								
Megistocera	+	+	+	-	+	-	-	+	+	-	+	-	+	-	+	+	-	-	+	-	+	+	+	+
Tendipes	-	-	-	-	-	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Antocha	-	-	+	+	-	-	-	-	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+
Dixa	+	-	-	-	+	+	+	+	-	+	-	-	+	+	-	+	+	-	+	-	-	+	-	-
Simulium	-	-	+	+	+	+	+	-	+	+	-	+	+	-	+	+	-	-	-	-	+	+	-	-
Coleoptera																								
Agabinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenocolus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heterlimnius	-	+	+	+	+	+	+	-	+	+	-	+	+	+	+	-	-	+	-	+	-	+	-	-
Hydaticus	+	-	-	-	+	+	+	+	-	-	+	-	+	+	-	+	-	-	+	+	+	-	-	-
Laccobius	-	+	+	+	-	-	-	-	+	-	+	+	+	-	+	+	+	+	+	+	+	+	+	+
Trichoptera																								
Hydropsyche	-	-	-	+	+	+	+	+	+	+	+	-	+	-	+	-	+	-	+	-	+	+	+	-
Hydroptella	+	-	+	-	+	-	-	-	-	+	+	+	+	+	-	-	-	+	-	+	-	-	-	-
Glossosoma	-	+	-	+	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Plecoptera																								
Perlomyia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Odonata																								
21. Argia	+	-	-	-	+	+	+	+	-	-	+	-	+	+	+	+	+	+	+	+	+	+	-	-
22. Hagenius	-	-	-	-	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
23. Epicordulia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24. Argion	-	-	-	-	-	+	+	-	+	+	-	+	-	-	+	+	-	-	-	-	+	-	-	-
25. Ophiogomphus	-	-	-	-	+	-	-	+	-	-	+	-	-	+	+	-	-	-	+	-	-	+	+	+
Total	**07**	**06**	**08**	**08**	**11**	**14**	**10**	**10**	**09**	**14**	**11**	**11**	**12**	**12**	**12**	**15**	**09**	**10**	**12**	**12**	**10**	**15**	**07**	**08**

Quantitative Abundance of Aquatic Entomofauna: The quatitative estimates are based on numerical count of animals collected from per square meter of river bed. The tables 5, 6 and 7 shows the average number of animals/sq.m at spot-1, spot-2 and spot-3, respectively in Goriganga river during 2006-07 and 2007-08. The highest percentage (36.66% and 36.48) of entomofaunal density was noticed at spot-3 (Madkot) during both the years where as the lowest (31.33%) was recorded at spot-1 (Jauljibi) during first year (2006-07) and (28.13%) at spot-2 (Baram) during second year (2007-8), (tables 5, 6, and 7). On the yearly basis a slight difference in quality was recorded in the present study, but a sharp variation was observed in entomo-faunal population at different spots.

It is also observed that Ephemeroptera were always high and Plecoptera were low than other groups of insects at all the collecting sites in the water. The annual percentage of aquatic insects during 2006-07 showed a relation i,e. Ephemeroptera (46.30%) > Diptera (17.56%) > Coleoptera (16.69%) > Trichoptera (10.32%) > Odonata (4.70%) > Plecoptera (4.41%) at spot-1 (Jauljibi) table 5; Ephemeroptera (47.14%) > Coleoptera (15.68%) > Diptera (14.30%) > Trichoptera (9.82%) > Odonata (6.92%) > Plecoptera (6.11%) at spot-2 (Baram) table 6 and Ephemeroptera (50.76%) > Diptera (17.02%) > Coleoptera (14.38%) > Trichoptera (10.92%) > Odonata (3.77%) > Plecoptera (3.13%) at spot-3 (Madkot) in the first year (2006-07) table 7, whereas during 2007-08 it was Ephemeroptera (51.28%) > Diptera (17.83%) > Coleoptera (17.45%) > Trichoptera (6.19%) > Odonata (3.91%) > Plecoptera (3.31%) at spot-1 (Jauljibi) table 5; Ephemeroptera (47.87%) > Coleoptera (15.47%) > Diptera (13.26%) > Trichoptera (11.10%) > Odonata (6.81%) > Plecoptera (5.42%) at spot-2 (Baram) table 6 and Ephemeroptera (48.73%) > Diptera (20.43%) > Trichoptera (12.16%) > Coleoptera (11.93%) > Odonata (4.22%) > Plecoptera (2.51%) at spot-3 (Madkot) table 7. The aquatic entomo-fauna both qualitatively

as well as quantitatively showed spot wise, monthly, seasonal and yearly fluctuations/variations in snow fed mountainous Goriganga river in the present study from July 2006 to June 2008 tables 1 to 8; figures 2, 3, 4, and 5. Generally, it was observed that increase in diversity and abundance of aquatic entomo-fauna depends on the type and size of particles comprising the substrate (substrate stability), minimum temperature and velocity of water, presence of organic detritus and occurrence of aquatic vegetation during winter season, hence winter time can be detrimental to aquatic entomo-fauna both in terms of quality and quantity. The diversity (quality) and abundance (quantity) of aquatic entomo-faunal population decreases during monsoon season may be because of maximum velocity (habitat destruction) and temperature of water, low turbidity and scarcity of aquatic vegetation in the Goriganga river during the entire course of study (i,e. from July 2006 to June 2008).

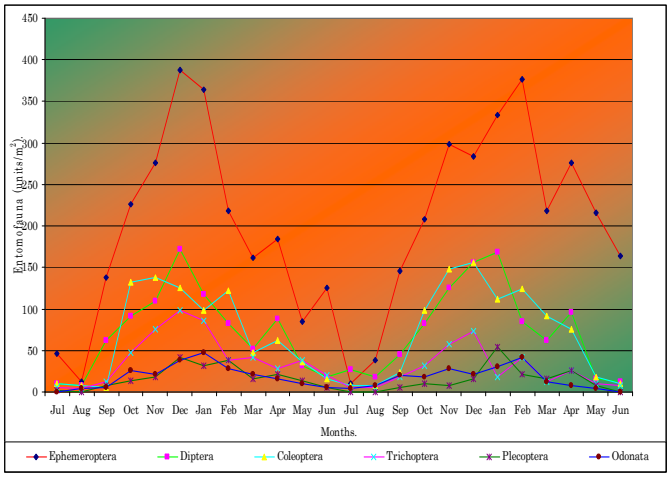

Figure-2
Monthly distribution of aquatic entomo-fauna at spot-1 (Jauljibi) in the Goriganga river during 2006-07 and 2007-08

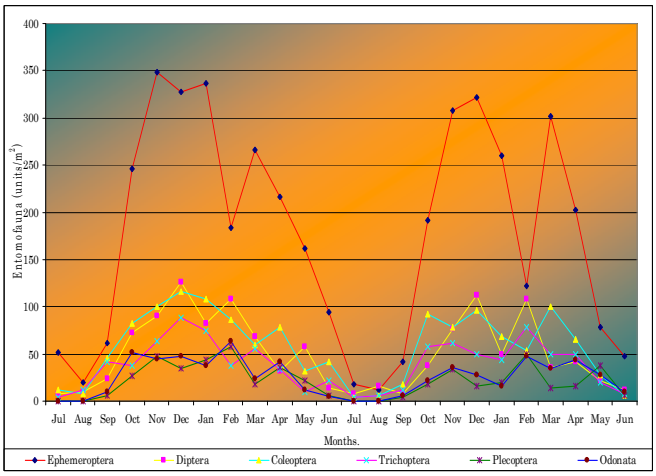

Figure-3
Monthly distribution of aquatic entomo-fauna at spot-2 (Baram) in the Goriganga river during 2006-07 and 2007-08

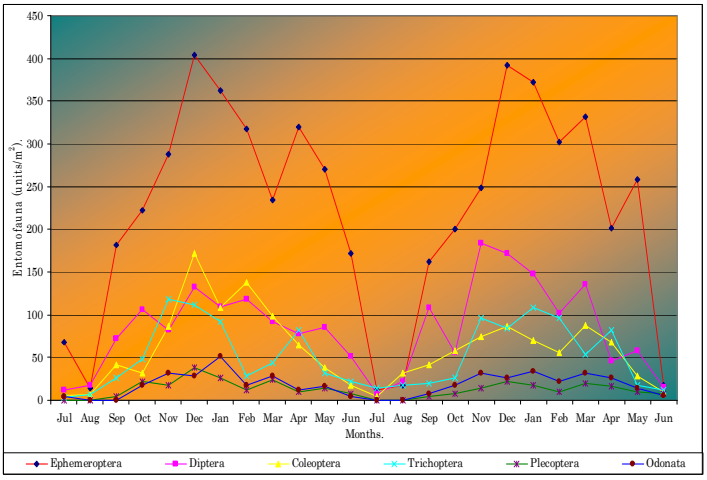

Figure-4
Monthly distribution of aquatic entomo-fauna at spot-3 (Madkot) in the Goriganga river during 2006-07 and 2007-08

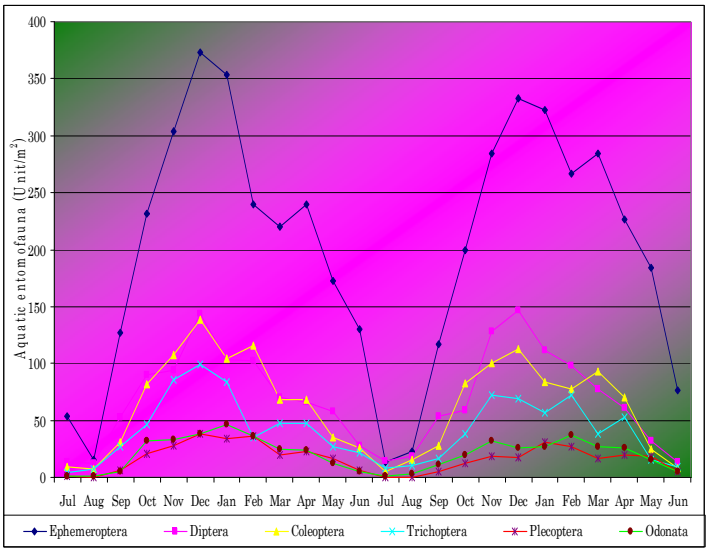

Figure-5
Monthly distribution of aquatic entomo-fauna (combined at three spots) in the Goriganga river during 2006-07 and 2007-08

On the basis of similarity index it was observed that there were close similarity among the taxa of Trichoptera (s = 0.66) during 2006-07 and (s = 0.66) among the taxa of Diptera during 2007-08 (table 9, figures 6 and 7), while no similarity (s = 0.00) was observed among the taxa of Coleoptera and Plecoptera during 2006-07 and among the texa of Plecoptera during 2007-08 in the present study (table 9, figures 6 and 7). The similarity index showed variations of aquatic insects in the different regions of the river. In determining the diversity and abundance of aquatic entomo-fauna in glacial fed mountainous Goriganga river, differences among environmental conditions are much more important than differences in spatial location.

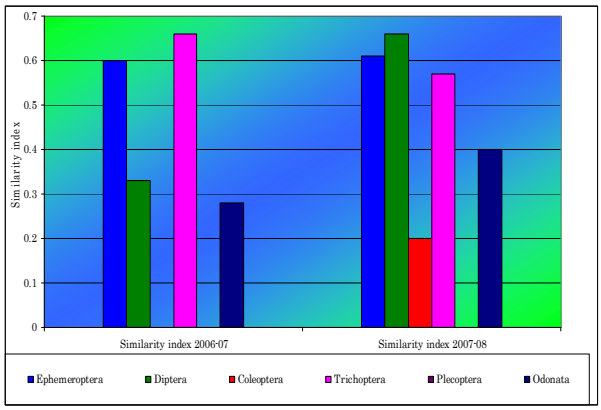

Figure-6
Similarity index among different groups of aquatic entomo-fauna in the Goriganga river during 2006-07 and 2007-08

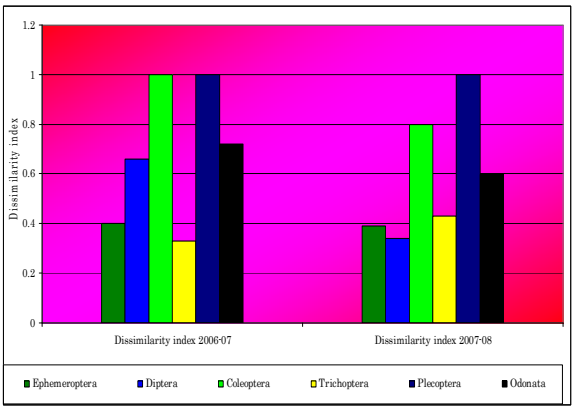

Figure-7
Dissimilarity index among different groups of aquatic entomo-fauna in the Goriganga river during 2006-07 and 2007-08

Table: 5
Quantitative abundance of aquatic entomo-fauna at Jauljibi (Spot-1) during 2006-07 and 2007-08

Months	Quantitative abundance of aquatic entomo-fauna at Jauljibi (Spot-1).													
	July 2006- June 07							July 2007- June 08						
	Ephemeroptera	Diptera	Coleoptera	Trichoptera	Plecoptera	Odonata	Total	Ephemeroptera	Diptera	Coleoptera	Trichoptera	Plecoptera	Odonata	Total
Jul	46 62.16%	10 13.51%	10 13.51%	6 08.10%	2 02.7%	0 0.00%	74 100%	10 18.18%	27 49.09%	8 14.54%	6 10.90%	0 0.00%	4 07.27%	55 100%
Aug	12 33.33%	8 22.22%	8 22.22%	4 11.11%	0 0.00%	4 11.11%	36 100%	38 48.71%	18 23.07%	8 10.25%	6 07.69%	0 0.00%	8 10.2%	78 100%
Sep	138 59.48%	62 26.72%	6 02.58%	12 05.17%	8 03.4%	6 02.58%	232 100%	146 56.37%	45 17.37%	24 09.26%	18 06.94%	6 02.31%	20 07.7%	259 100%
Oct	226 42.00%	92 17.10%	132 24.53%	48 08.92%	14 02.6%	26 04.83%	538 100%	208 46.42%	82 18.30%	98 21.87%	32 07.14%	10 02.23%	18 04.0%	448 100%
Nov	276 43.12%	110 17.18%	138 21.56%	76 11.87%	18 02.8%	22 03.43%	640 100%	298 44.74%	126 18.91%	148 22.22%	58 08.70%	8 01.20%	28 04.2%	666 100%
Dec	388 44.90%	172 19.90%	126 14.58%	98 11.34%	42 04.8%	38 04.39%	864 100%	284 40.11%	156 22.03%	156 22.03%	74 10.45%	16 02.25%	22 03.1%	708 100%
Jan	364 48.79%	118 15.81%	98 13.13%	86 11.52%	32 04.2%	48 06.43%	746 100%	334 46.64%	168 23.46%	112 15.64%	18 02.51%	54 07.54%	30 04.1%	716 100%
Feb	218 41.44%	82 15.58%	122 23.19%	38 07.22%	38 07.2%	28 05.32%	526 100%	376 54.41%	85 12.30%	124 17.94%	42 06.07%	22 03.18%	42 06.0%	691 100%
Mar	162 47.36%	52 15.20%	48 14.03%	42 12.28%	16 04.6%	22 6.43%	342 100%	218 52.91%	62 15.04%	92 22.33%	12 02.91%	16 03.88%	12 02.9%	412 100%
Apr	184 46.00%	88 22.00%	62 15.50%	28 07.00%	22 05.5%	16 04.00%	400 100%	276 54.33%	96 18.89%	76 14.96%	26 05.11%	26 05.11%	8 01.5%	508 100%
May	85 39.53%	32 14.88%	36 16.74%	38 17.67%	14 06.5%	10 04.65%	215 100%	216 79.41%	16 05.88%	18 06.61%	10 03.67%	8 02.94%	4 01.4%	272 100%
Jun	126 65.62%	18 09.37%	16 08.33%	20 10.41%	6 03.1%	6 03.12%	192 100%	164 84.53%	12 06.18%	10 05.15%	8 04.12%	0 0.000%	0 0.00%	194 100%
Total	2225	844	802	496	212	226	4805	2568	893	874	310	166	196	5007
Annual (%)	46.30%	17.56%	16.69%	10.32%	4.41%	4.70%	100%	51.28%	17.83%	17.45%	6.19%	3.31%	3.91%	100%

Table: 6
Quantitative abundance of aquatic entomofauna at Baram (Spot-2) during 2006-07 and 2007-08

Months	Quantitative abundance of aquatic entomofauna (Unit/m^2) at Baram (Spot-2).													
	July 2006- June 07							July 2007- June 08						
	Ephemeroptera	Diptera	Coleoptera	Trichoptera	Plecoptera	Odonata	Total	Ephemeroptera	Diptera	Coleoptera	Trichoptera	Plecoptera	Odonata	Total
Jul	52 60.4%	18 20.9%	12 13.9%	4 04.6%	0 0.0%	0 0.00%	86 10%	18 52.9%	8 23.5%	4 11.7%	4 11.7%	0 0.00%	0 0.00%	34 100%
Aug	20 40.00%	10 20.00%	8 16.00%	12 24.00%	0 0.00%	0 0.00%	50 100%	12 30.00%	16 40.00%	6 15.00%	6 15.0%	0 0.00%	0 0.00%	40 100%
Sep	62 32.63%	24 12.63%	46 24.21%	42 22.10%	6 03.1%	10 05.26%	190 100%	42 46.66%	8 08.88%	18 20.00%	12 13.3%	4 04.44%	6 06.6%	90 100%
Oct	246 47.58%	72 13.92%	82 15.86%	38 07.35%	27 05.2%	52 10.05%	517 100%	192 45.71%	38 09.04%	92 21.90%	58 13.8%	18 04.28%	22 05.2%	420 100%
Nov	348 50.07%	90 12.94%	100 14.38%	64 09.20%	48 06.9%	45 06.47%	695 100%	308 51.85%	76 12.79%	78 13.13%	62 10.4%	34 05.72%	36 06.0%	594 100%
Dec	328 44.26%	126 17.00%	116 15.65%	88 11.87%	35 04.7%	48 06.47%	741 100%	322 48.64%	112 16.91%	96 14.50%	50 07.5%	38 05.74%	44 06.6%	662 100%
Jan	336 49.26%	82 12.02%	108 15.83%	74 10.85%	44 06.4%	38 05.57%	682 100%	260 51.28%	50 09.86%	68 13.41%	44 08.6%	50 09.86%	35 06.9%	507 100%
Feb	184 34.20%	108 20.07%	86 15.98%	38 07.06%	58 10.7%	64 11.89%	538 100%	122 28.37%	108 25.11%	54 12.55%	78 18.1%	20 04.65%	48 11.1%	430 100%
Mar	266 54.06%	68 13.82%	60 12.19%	56 11.38%	18 03.6%	24 04.87%	492 100%	302 58.30%	36 06.94%	100 19.30%	50 09.6%	14 02.70%	16 03.0%	518 100%
Apr	216 49.31%	32 07.30%	78 17.80%	34 07.76%	36 08.2%	42 09.58%	438 100%	202 50.00%	42 10.39%	66 16.33%	50 12.3%	16 03.96%	28 06.9%	404 100%
May	162 54.72%	58 19.59%	32 10.81%	10 03.37%	22 07.4%	12 04.05%	296 100%	78 40.62%	22 11.45%	28 14.58%	20 10.4%	16 08.33%	28 14.5%	192 100%
Jun	94 51.36%	14 07.65%	42 22.95%	22 12.02%	6 03.2%	5 02.73%	183 100%	48 53.33%	12 13.33%	6 06.66%	8 08.8%	6 06.66%	10 11.1%	90 100%
Total	2314	702	770	482	300	340	4908	1906	528	616	442	216	273	3981
Annual (%)	47.14%	14.30%	15.68%	09.82%	06.1%	06.92%	100%	47.87%	13.26%	15.47%	11.1%	05.42%	06.8%	100%

Table-7
Quantitative abundance of aquatic entomo-fauna at Madkot (Spot-3) during 2006-07 and 2007-08

Months	Quantitative abundance of aquatic entomo-fauna (Unit/m^2) at Madkot (Spot-3)													
	July 2006- June 07							July 2007- June 08						
	Ephemeroptera	Diptera	Coleoptera	Trichoptera	Plecoptera	Odonata	Total	Ephemeroptera	Diptera	Coleoptera	Trichoptera	Plecoptera	Odonata	Total
Jul	68 73.91%	12 13.04%	5 05.43%	3 03.26%	0 0.00%	4 04.34%	92 100%	12 31.57%	8 21.05%	4 10.52%	14 36.84%	0 0.00%	0 0.00%	38 100%
Aug	14 30.43%	18 39.13%	7 15.21%	7 15.21%	0 0.00%	0 0.00%	46 100%	18 20.00%	22 24.44%	32 35.55%	18 20.00%	0 0.00%	0 0.00%	90 100%
Sep	182 55.82%	72 22.08%	42 12.88%	26 07.97%	4 01.22%	0 0.00%	326 100%	162 47.09%	108 31.39%	42 12.20%	20 05.81%	4 01.16%	8 02.3%	344 100%
Oct	222 49.55%	106 23.66%	32 07.14%	48 10.71%	22 04.91%	18 04.01%	448 100%	200 54.64%	56 15.30%	58 15.84%	26 07.10%	8 02.18%	18 04.9%	366 100%
Nov	288 46.15%	82 13.14%	86 13.78%	118 18.91%	18 02.88%	32 05.12%	624 100%	248 38.27%	184 28.39%	74 11.41%	96 14.81%	14 02.16%	32 04.9%	648 100%
Dec	404 45.59%	132 14.89%	172 19.41%	112 12.64%	38 04.28%	28 03.16%	886 100%	392 50.12%	172 21.99%	86 10.99%	84 10.74%	22 02.81%	26 03.3%	782 100%
Jan	362 48.26%	110 14.66%	108 14.40%	92 12.26%	26 03.46%	52 06.93%	750 100%	372 49.6%	148 19.73%	70 09.33%	108 14.40%	18 02.40%	34 04.5%	750 100%
Feb	318 50.31%	118 18.67%	138 21.83%	28 04.43%	12 01.89%	18 02.84%	632 100%	302 51.36%	102 17.34%	56 09.52%	96 16.32%	10 01.70%	22 03.7%	588 100%
Mar	234 45.00%	92 17.69%	98 18.84%	44 08.46%	24 04.61%	28 05.38%	520 100%	332 50.15%	136 20.54%	88 13.29%	54 08.15%	20 03.02%	32 04.8%	662 100%
Apr	320 56.43%	78 13.75%	65 11.46%	82 14.46%	10 01.76%	12 02.11%	567 100%	202 45.90%	46 10.45%	68 15.45%	82 18.63%	16 03.63%	26 05.9%	440 100%
May	270 59.34%	85 18.68%	38 08.35%	32 07.03%	14 03.07%	16 03.51%	455 100%	258 66.83%	58 15.02%	28 07.25%	18 04.66%	10 02.59%	14 03.6%	386 100%
Jun	172 62.31%	52 18.84%	18 06.52%	22 07.97%	8 02.89%	4 01.44%	276 100%	18 26.08%	15 21.73%	10 14.49%	12 17.39%	8 11.59%	6 08.6%	69 100%
Total	2854	957	809	614	176	212	5622	2516	1055	616	628	130	218	5163
Annual (%)	50.76%	17.02%	14.38%	10.92%	03.13%	03.77%	100%	48.73%	20.43%	11.93%	12.16%	2.51%	4.22%	100%

Discussion: Some 25 genera of aquatic insects belonging to Ephemeroptera (05, 20.0 %), Diptera (05, 20.0 %), Coleoptera (05, 20.0 %), Trichoptera (03, 12.0 %), Plecoptera (02, 8.0 %) and Odonata (05, 20.0 %) were recorded in Goriganga river during the course of study. The aquatic entomofaunal diversity and abundance in Goriganga river was accessed to be influenced by water movement and nature of surfaces available for colonization especially sediment particle size. The riverine ecosystem of Goriganga comprised of substrate ranging from small gravel to boulders.

The structure of substratum is one of the main factors controlling aquatic insect population. The physical complex substrate type (leaves, gravel or cobbles, macrophytes, mose and wood) generally support more diversity than simple substratum such as sand and bedrock as also recorded by Angradi[31] and Hawkes[32]. Whitton[33] have reported that the biotic, physical and chemical parameters that integrate to form the environmental milieu to which diversity and abundance of plankton and aquatic insects depend, certain ones appear to be more direct in their mode of control. Excluding various degrees of human perturbation (such as abnormally high light intensities, low oxygen levels, or organic and inorganic nutrient loads), the availability of food, nature of sediment and current flow generally constitute the parameters of primary significance in determining the distribution and abundance patterns of plankton and aquatic insects.

The benthic population affected by substratum in such conditions have been reported by Nautiyal[34]; Singh et.al.[35]; Upadhyay[36] and Mahar[37], similar to the present study on entomofauna. Aquatic insects population reached the abundance during winter and summer in the Goriganga river due to the reason that their population and distributional pattern were influenced by velocity, temperature, pH and substrate suitability. All these factors might have influenced the nature of surface available for colonization Cummins[38]. Balodi et.al.[39] have reported a maximum of 1144 units/meter^2 in the Eastern Nayar at Dangal and 799 units/meter^2 in the high altitude Western Nayar at Thalisain, while Negi[40] reported a maximum of 566 units units/meter^2 in snow fed stream Alaknanda. But in the present study a maximum of 404 and 392 units/meter^2 have been recorded in the month of December during 2006-07 and 2007-08 respectively.

Mayflies (Ephemeroptera) dominated all other group of aquatic insects in abundance in Goriganga river as also supported by Dobriyal et.al. from river Nayar; Negi[41] from Mandakini river and Rautela et.al.[42] from river Khoh;. The maximum population of aquatic entomofauna was observed during winter season and minimum during the monsoon season. The low aquatic entomofauna population during monsoon might be due to high velocity of water and substratum of big stones which do not support aquatic entomofauna as also reported by Rautela et.al.[42] in Khoh river, Garhwal Himalaya, similar to the present study.

Table: 8
Seasonal changes of aquatic entomofauna percentage to the total aquatic entomofauna population

Order / Genera	July 2006-June 2007			July 2007-June 2008		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Ephemeroptera						
Spot-1	14.47%	56.35%	29.16%	13.94%	43.76%	42.28%
Spot-2	9.85%	54.36%	35.78%	6.29%	56.76%	36.93%
Spot-3	15.27%	44.70%	40.01%	8.34%	48.17%	43.48%
Diptera						
Spot-1	11.61%	58.29%	30.09%	11.42%	59.57%	29.00%
Spot-2	9.40%	52.70%	37.89%	8.33%	52.77%	39.39%
Spot-3	16.09%	44.93%	39.39%	14.50%	53.08%	32.41%
Coleoptera						
Spot-1	4.98%	61.59%	33.41%	5.72%	58.81%	36.38%
Spot-2	14.02%	52.72%	33.24%	5.51%	54.22%	40.25%
Spot-3	8.89%	49.19%	41.90%	14.28%	46.75%	38.96%
Trichoptera						
Spot-1	8.46%	62.09%	29.43%	12.25%	58.70%	29.03%
Spot-2	16.59%	54.77%	28.63%	6.78%	48.41%	44.79%
Spot-3	9.44%	60.26%	30.29%	10.19%	50.00%	39.80%
Plecoptera						
Spot-1	7.54%	50.0%	42.45%	3.61%	53.01%	43.37%
Spot-2	4.0%	51.33%	44.66%	4.62%	64.81%	30.55%
Spot-3	6.81%	59.09%	34.09%	9.23%	47.69%	43.07%
Odonata						
Spot-1	7.07%	59.29%	33.62%	16.32%	50.00%	33.67%
Spot-2	4.41%	53.82%	41.76%	5.86%	50.18%	43.95%
Spot-3	3.77%	61.32%	34.90%	6.42%	50.45%	43.11%

Table-9
Similarity and Dissimilarity Index among different groups of aquatic entomo-fauna in the Goriganga river during 2006-07 and 2007-08

Order/Group	Similarity index		Dissimilarity Index	
	2006-07	2007-08	2006-07	2007-08
Ephemeroptera	0.6	0.61	0.4	0.39
Diptera	0.33	0.66	0.66	0.34
Coleoptera	0.00	0.2	1.0	0.8
Tricoptera	0.66	0.57	0.33	0.43
Plecoptera	0.00	0.00	1.0	1.00
Odonata	0.28	0.4	0.72	0.6

Conclusion

The present study concluded that Out of 25 genera of aquatic insects, 8 genera (*Ephemerella, Cinygmula, Baetisca, Megistocera, Antocha, Hydropsyche, Hydroptella* and *Argia*) were fairly common at all the spots. The Ephemeroptera (mayflies) nymps, Coleoptera (water beetles) both larvae and adults and Odonata (dragonflies) formed the major bulk, the Diptera (true flies), Trichoptera (caddisflies) and Plecoptera (stoneflies) were next in the line. The aquatic insects were generally found concealed under stones, gravel and rocks. The stone flies (Plecoptera) were present exclusively in the riffles and Odonata (dragon flies) and Coleoptera (water beetles) in slow and stagnant conditions. Others such as mayflies (Ephemeroptera), Caddisflies (Trichoptera), trueflies (Diptera) were common to both the habitats. The maximum population of aquatic entomofauna was observed during winter season and minimum during the monsoon season. The low aquatic entomofauna population during monsoon might be due to high velocity of water and substratum of big stones which do not support aquatic entomofauna.

On the basis of above facts, it is finally concluded that water quality of glacial fed mountainous goriganga river can be considered as clean based on the observations made on the diversity and abundance of aquatic entomo-fauna. Aquatic insects not only enhance the river nutrient cycling through their feeding strategies, but also support communities of higher organisms like fish, frog and others.

Acknowledgements

The author is highly thankful to Uttrakhand Council of Science and Technology -UCOST, Dehradun for providing financial support to carry out this work very successfully.

References

1. Mittermeier R.A., Fonseca G.A.B., Rylands A.B. and Mittermeier C.G., In: R.A. Mittermeier, P. Robles Gil and C.G. Mittermeier (Eds). Megadiversity: Mexico: 39-49 **(1997)**

2. Dudgeon D., Tropical Asian Streams: Zoobenthos, Ecology and Conservation, Hong Kong University Press **(1999)**

3. Merritt R.W., Cummins K.W. and Berg M.B., An introduction to aquatic insects of North America, 4th Edition; 1158 **(2008)**

4. Foil L.D., Tabanids as vectors of disease agents, *Parasitol. Today,* **5**, 88-96 **(1998)**

5. Chae S.N., Purstela N., Johnson E., Derock E., Lawler S.P. and Purstela E., Infection of aquatic insects with trematode metacercaria carrying Ehrilichia restricticii, the case of potamac house fever, *J.Med. Entomol,* **37,** 619-625 **(2000)**

6. Pahw D.V., *Indian Journal of animal Science,* **49**, 212-219 **(1979)**

7. Sharma R.C., Seasonal abundance of phytoplankton in the Bhagirathi river, Garhwal Himalaya, *Indian J. Ecol.,* **12(1)**, 157-160 **(1985)**

8. Sunder S. and Sulbla B.A., Macrobenthic Fauna of a Himalayan river, *Indian Journal of Ecology,* **13,** 127-132 **(1986)**

9. Bhatt S.D., Bisht Y. and Negi U., Ecology of limnofauna in the river Kosi of the Kumaun Himalaya (Uttar Pradesh), *Proc. Natn. Sci.Acad., B,* **50(4),** 395-405 **(1984)**

10. Dutta S.P.S. and Malhotra Y.R., Seasonal variations in the macrobenthic fauna of Dadigarh stream (Miran Sahib), Jammu, *Inland J. Ecol.,* **13**, 138-14 **(1986)**

11. Sinha M.P., Pandey N. and Mehrotra P.N., *Indian Zoologists*, **13**, 79-83 **(1989)**

12. Pathani S. S., Fsih survey in relation to management of fishery resources in Kumaun Uttatanchal, *Final Progress Report, UCOST, Dehradun* **(2008)**

13. Hynes H. B. N., The Ecology of Running Waters: *Liverpool university press, Liverpool,* 543 **(1970)**

14. Gupta S., Dey S. and Purkayyastha P., Use of aquatic insects in water quality assessment of ponds around two cement factories of Assam, India., *International research journal of Environmental Sciences,* **2(7),** 15-19 **(2013)**

15. Mohan V.C., Sharma K.K. and Watts P., Biodiversity and abundance of benthic macro-invertebrates community of river Tawi in vicinity of Udhampur city (J&K) India, *International research journal of Environmental Sciences,* **2(5),** 17-24 **(2013)**

16. Welch P. S. *Limnology, Mc Graw, Hill Co. Book Company, New Yrk.* 538 **(1952)**

17. Ward H.B. and Whipple G.C., Fresh Water Biology, *In W.T. Edmondson (Ed.), 2nd Wiley, New York.,* 1248 **(1959)**

18. Pennak R.W., In: Fresh water invertebrates of United states, *John Willey and Sons New York,* **(1978)**

19. Tonapi G.T., Fresh Water Animals of India: An Ecological Approach, Oxford and IBH Publishing Co., New Delhi **(1980)**

20. Sharma K.K., Langer S. and Sharma R., water quality and macrobenthic invertebrate fauna of Behol nullah, Jammu (J&K), *International research journal of Environmental Sciences,* **5(3&4),** 111-115 **(2011)**

21. Dobriyal A. K., Ecology of limno-fauna in the small streams and their importance to the village life of Garhwal Himalayas, *Uttar Pradesh J. Zool,* **5(2)** 139-144 **(1985)**

22. Sehgal K. LDistributional pattern, structural modifications and diversity of benthic biota in mountain streams of NW Himalaya, In: Ecology of the Mountain Waters. *(Eds.)*

Bhatt, S. D. Pandey, R. K. Aashish Publishing House, New Delhi, 198-250 **(1991)**

23. Negi M., Phytobenthos of the hill stream Alaknanda of Garhwal Himalaya. In: Advances in limnology, *(Eds.) Singh, H. R.. Narendra Publishing House, Delhi,* 139-144 **(1993)**

24. Jhingran A.G., Impact of environmental stress on fresh water fisheries resources, *J. Inland fish. Soc. India,* **23(2)**, 20-32 **(1991)**

25. Pathani S.S., Upadhayay K.K. and Joshi S.K., Some Physico-chemical Parameters and Primary Productivity of river west Ramganga (Uttarnchal), *Him. J. Env. Zool.,* **16(2)**, 151-158 **(2002)**

26. Vass K.K. and Zultshi D.P., Energy flow, trophic evaluation and ecosystem management of Kashmir Himalayan lake, *Arch. Hydrobiol.* **97**, 39-59 **(1983)**

27. Vollenweider R.A., A manual on methods for measuring productivity in Aquatic Environment, I.B.P. Hand Book No. 12. *Blackwell Scientific Publications, Oxford and Edinburgh,* **(1969)**

28. Hynes H.B.N., The Ecology of Running Waters: Liverpool University Press. Liverpool, **555 (1979)**

29. Trivedy R.K. and Goel P.K. Chemical and biological methods for water pollution studies, *Enviornment al publications, Karda, 248* **(1986)**

30. Odum E.P., Fundamentals of Ecology, *Natraj Publishers Dehradun.,* 574 **(1971)**

31. Angradi T.R., Inter-habitat variation in benthic community structure function and organic matter storage in three (3) appalachian head water streams, *J. Am. Benthos Lim. Soc.,* **15,** 42-63 **(1996)**

32. Hawkes H.A., River zonation and classification, In: River Ecology, (ed.) B. A. Whitton, Blackwell Sci. Publication, Oxford, 132-374 **(1975)**

33. Whitton B.A., (Eds.) River Ecology, Blackwell Scientific Publication, Oxford, 711 **(1975)**

34. Nautiyal P., Studies on the riverine ecology of torrential waters in the Indian uplands of the Garhwal region. III. Floristic and faunal survey, *Trop. Ecol.,* **27**, 157-165 **(1986)**

35. Singh H.R., Nautiyal P., Dobriyal R.C., Pokhriyal R.C., Negi M., Baduni V., Nautiyal R., Agarwal N.K., Pautiyal P. and Gautam A., Water quality of river Ganga (Garhwal Himalaya), *Acta Hydrobiologia,* **36(1),** 3-15 **(1994)**

36. Upadhyay K.K., Productivity and energy flow in the Ramganga (W) river system in Kumaun Himalaya, *Ph.D. Thesis Kumaun University Nainital* **(2002)**

37. Mahar S., Ecology of the suyal river of the Kumaun Himalaya, *Ph.D. Thesis, K.U. Nainital* **(2002)**

38. Cummins K.W., Trophic Relations of Aquatic Insects, *Ann. Rev. of Entomol.,* **18**, 183-206 **(1973)**

39. Balodi Y.P., Dobriyal A.K., Thaphyal A. and Bisht M.S., Benthic diversity and related ecologyical parameters in the hill stream Eastern Nayar of Garhwal Himalaya, Uttaranchal, *National Symposium on Status of India's Faunistic Diversity & Environment, All India Congress of Zoology, Dec. 29-31, GKU-Hardwar, Abstract No. 122: 54* **(2000)**

40. Negi M., Ecological studies of the Benthic Communities of the river Alaknanda of Garhwal Himalaya. *Ph.D. Thesis. H. B. N. Garhwal University, Srinagar,* **(1989)**

41. Negi M. Ecological studies of the Benthic Communities of the river Alaknanda of Garhwal Himalaya. *Ph.D. Thesis. H. B. N. Garhwal University, Srinagar,* **(1998)**

42. Rautela K.K., Kumar K., Bisht K.L., Joshi V.D., Negi K.S., Rautela A.S. and Dobriyal A.K., Ecological studies on biodiversity of river Khoh in the foot hills of Garhwal Himalayal, Part II : Macro-zoobenthic analysis, *Aquaculture,* **7(2)**, 277-283 **(2006)**